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Aidan McDonald
Neuroscience Historical Paper

Attempting to Mimic the Brain Synthetically

Since the advent of the microprocessor, and the proliferation of computational devices, humans have speculated and dreamed about the rise of artificial intelligence. Whether in movies, books, the media or video games, the idea of intelligent machines has sparked a great amount of interest, and an equal amount of controversy. In its most basic definition, artificial intelligence can be thought of as robots and machines that have their own independent level of intelligence. Expanding the definition any more will result in taking some side in the hugely multi-faceted field that is AI. One large camp of artificial intelligence, that has been mainly unsuccessful so far, has been centered on the thought that you can create a machine that mimics the processes and functions of the brain. Much of this camp believes that if the fundamental unit of the computer were to be equivalent in function to the fundamental unit of the brain, then the higher level functions would also be similar. Others predicted that synthetic intelligence could be achieved through feed forward artificial neural networks that simulate processes in the neural networks of the brain. Unfortunately, this branch of artificial intelligence that centers on re-inventing the brain has met with failure because of fundamental difficulties that arise when dealing with an 'organic computer' such as, or only as (since it is the only one discovered so far), the brain.

One approach to artificial intelligence, and the study of the brain, is the reductionist approach. This philosophy believes that any object can be described in terms of some other 'lesser' entity. For example, this is one major theory in molecular biology, in that the processes of the cell can be described in terms of the processes of specific intracellular bodies, which can be in turn described by their chemical composition. However, this theory can become confusing when in the framework of neuroscience and brain psychology. "One reason lies in the confusion of reduction with reductionism. This is based on equating the knowledge involved in the means used to reach a goal with the goal itself" (1). For example, a physiological psychologist stimulates and measures the physical properties of the brain (and therefore simplifies its function physically), while the experimental psychologist might solely study the behavior of that individual. On the computation side of things, Willshaw et al. (2) believes that "levels are a reflection of the physical world. Working from the bottom, there is the device level, the circuit level, the logic circuit sub-level, the symbol level, and… the highest level is the knowledge level".But just because we can break down an object into its smallest possible pieces, and we can understand those pieces, doesn't mean we can understand the object as a whole. Teitelbaum and Pellis argue that there are "discontinuities between levels of analysis that cannot now be bridged. These form natural boundaries between the sciences that operate at different levels of analysis" (1). Willshaw et al. (2) highlights the fact that "in the nervous system there are organized structures on different scales: 'molecules, synapses, neurons, networks, layers, maps and systems'". Now the question might arise of: What level might neuroscience operate on? The obvious answer is on the neuron level. Coming back to the topic of artificial intelligence, one might wonder if there are biophysical and molecular processes at this neuron level to implement a 'spiking computer' that mimics the brain.

Bell answers with a decisive "no" (3). Unlike the gate-level processes in a computer which have no processes below it that interfere with the operation of a computer, the neuron level of the brain has sub-neuronal interference. Below the level of the neuron "molecular and biophysical process control the sensitivity of neurons to incoming spikes (both synaptic efficiency and post-synaptic responsively), the excitability of the neuron to produce spikes, the patterns of spikes it can produce and the likelihood of new synapses forming (dynamic rewiring)" (3). These are just a few of the sub-neuronal processes that influence higher up processes. Well what if we continue the reductionist approach and go to the molecular level? Perhaps this level will shed some light on the processes. Again, Bell refutes this theory, stating that one would have to have knowledge of all the positions of the molecules of the brain in order to create a molecular computer. But here we run aground of another problem. Molecules behave differently in nature than they do in machines, due to sub-molecular interferences (3). Perhaps Horgan (4) is right in saying "AI so far has been a failure… the best that computer scientists can hope to do is to create machines 'that will know a great deal about what they are supposed to know and miserably little about anything else'". Everything that we design about these types of computers are limited by the knowledge that we put into them.

So what if the computer could learn by itself? This is the basic idea behind neural networks. A neural network is composed of "a set of simple computing units which influence each other through modifiable connections, or weights. The activity of each unit at any moment of time is determined by the combined effect of the activities of the units which influence it, as modulated by the strengths of the appropriate weights" (2). One of the primary ways of thought is that of the feed forward neural network. In this, one set of units receive the inputs, one set sends the outputs, and there can be hidden units between the input and the output make the network more powerful. These artificial networks were made to model brain neural networks, but they have a few problems. One is presented by Clocksin (5) who notes that no matter if a problem is being solved by a typical algorithm or by a neural network, "the computer is still carrying out an abstract task in isolation, defined and specified in a way judged appropriate by its author". This so called 'machine learning' is actually human influenced from the start, raising questions about whether it can truly ever become artificial intelligence. Neural networks also can be boiled down to "conventional curve fitting or parameter estimation of one sort or another" (5). But the biggest issue with feed forward neural networks is that "feed-forward processing in the nervous system is the exception rather than the rule, and often what looks feed-forward contains complicated feedback systems at a different level of analysis… this destroys the illusion that the neuron works like a direction 'neural network' neuron, performing a weighted sum of its input signals" (3). The biological neural networks are a complicated series of feedback and feed forward loops with various layers of signal processing in between.

It seems that nature has naturally created a unique processing organ incapable of being artificially replicated. Whether we attempt to mimic it through base level discrete processors, or by higher level networks, we run into seemingly insurmountable challenges of complexity which the brain has developed quite easily. It seems that artificial intelligence is something to only fantasize about, as Bell states bluntly: "There will be no machines with minds" (3). There will be no robot police force protecting humans, nor HAL-like computers that try to enforce their own form of morality. But then what is next for the technological revolution that we have created? The integration of humans with synthetics seems more plausible. Already Americans have become inseparable from their smartphones; they are now just mere extensions of the human form. Robotic limbs have been on the rise, as have artificial hearts and other vital organs. Brain implants have been used to help patients recover lost areas from a stroke or from head injuries.

This raises an important question about the human ship of Theseus, and at what point we lose what it means to be us.

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